Current Status and Future Challenges of Fuel Debris Retrieval

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Nuclear Damage Compensation and
Decommissioning Facilitation Corporation (NDF)
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I. Introduction

1. Understanding of the Current Status at Fukushima Daiichi

✓ 14 years after the accident, the site is in a relatively stable state.

- Steady progress has been made in efforts to reduce risks at Fukushima Daiichi

✓ Decommissioning of Fukushima Daiichi is progressing toward the phase of large-scale fuel debris retrieval.

- Trial fuel debris retrieval have been conducted twice, moving into the Phase 3 in the Mid-and-Long-term Roadmap.
- Conceptual studies for large-scale retrieval are also underway.

✓ Work safety will become even more crucial in the future.

- During the first trial retrieval, multiple operational problems occurred, and workers' radiation doses also increased.
- **Ensuring "work safety" is the Primary prerequisite for future efforts.**
  - ✓ Larger-scale retrieval and longer work periods lie ahead.
  - ✓ Flexible responses are essential at the site with a high degree of uncertainty.

2. Structure of This Forum

1. **Following a presentation on the current status** of decommissioning and fuel debris retrievals at Fukushima Daiichi,
2. **We will assume potential future challenges** and **study countermeasures**
   - ✓ Learn from past experiences, including overseas cases
   - ✓ Consider not only individual technical challenges but also how to ensure overall progress with the decommissioning work

With **work safety** as the top priority,
we will discuss and study a **realistic** and **sustainable** path towards the fuel debris retrieval

3. Structure of This Presentation

1. Status Report

Two topics regarding efforts toward the fuel debris retrieval will be presented:

- **Overview of the two trial retrievals**
- **Status of engineering studies for full-scale retrieval**

2. Raising issues

This presentation will outline potential challenges foreseen as we proceed with the decommissioning of the Fukushima Daiichi Nuclear Power Station, particularly the fuel debris retrieval.

- ✓ **It will cover not only individual technical challenges but also how to ensure overall progress with the decommissioning work.**

II. Overview of Trial Retrieval

1. Overview of Trial Retrieval

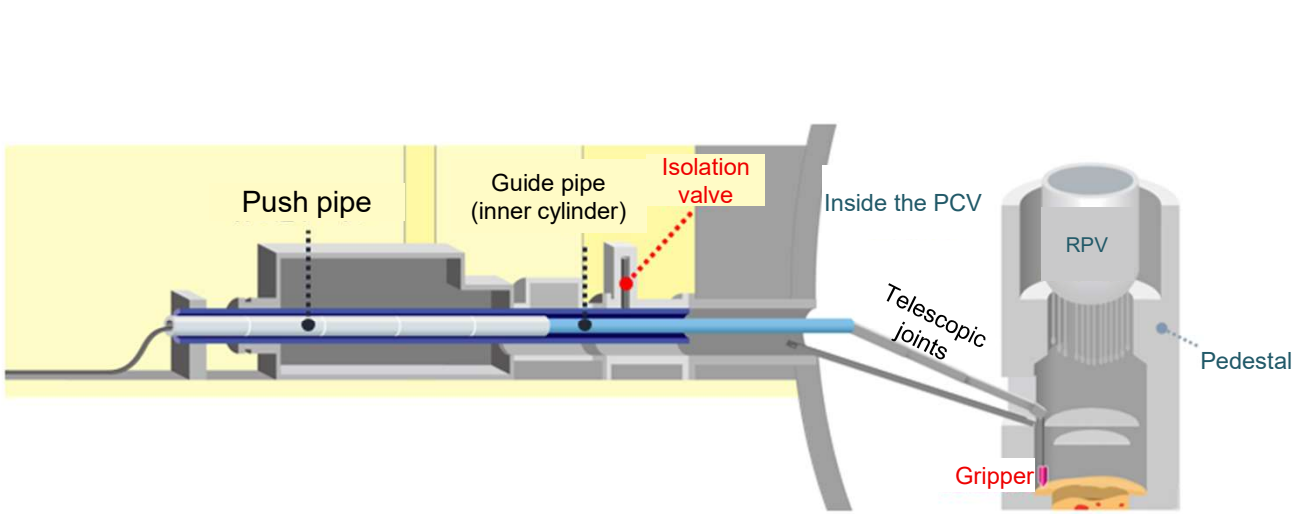
Between November last year to April this year, two trial retrievals were performed in Unit 2.

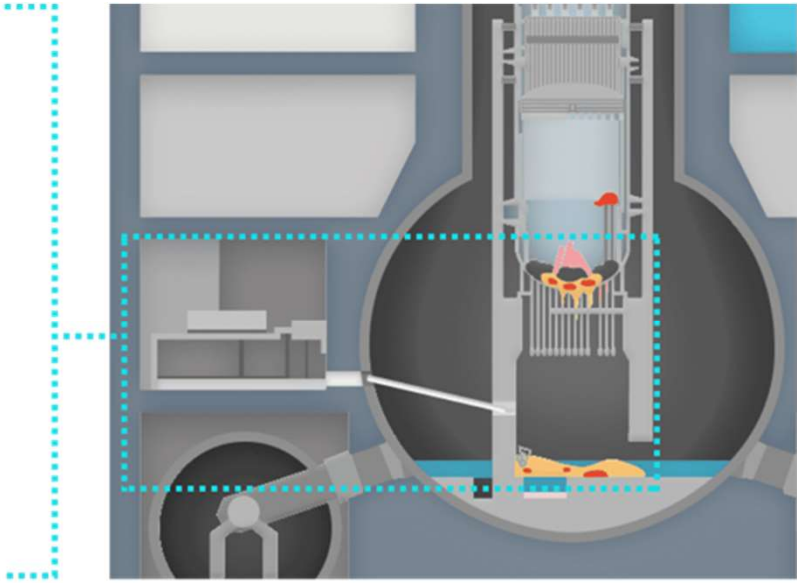
- Information from inside the pedestal and samples of fuel debris were obtained

  ➡ This will contribute to accident analysis and engineering studies through future analysis

- The containment boundary was extended to the outside of the PCV, telescopic equipment was installed and a telescopic joints were inserted

  ➡ This will be a basic approach for future retrieval work.

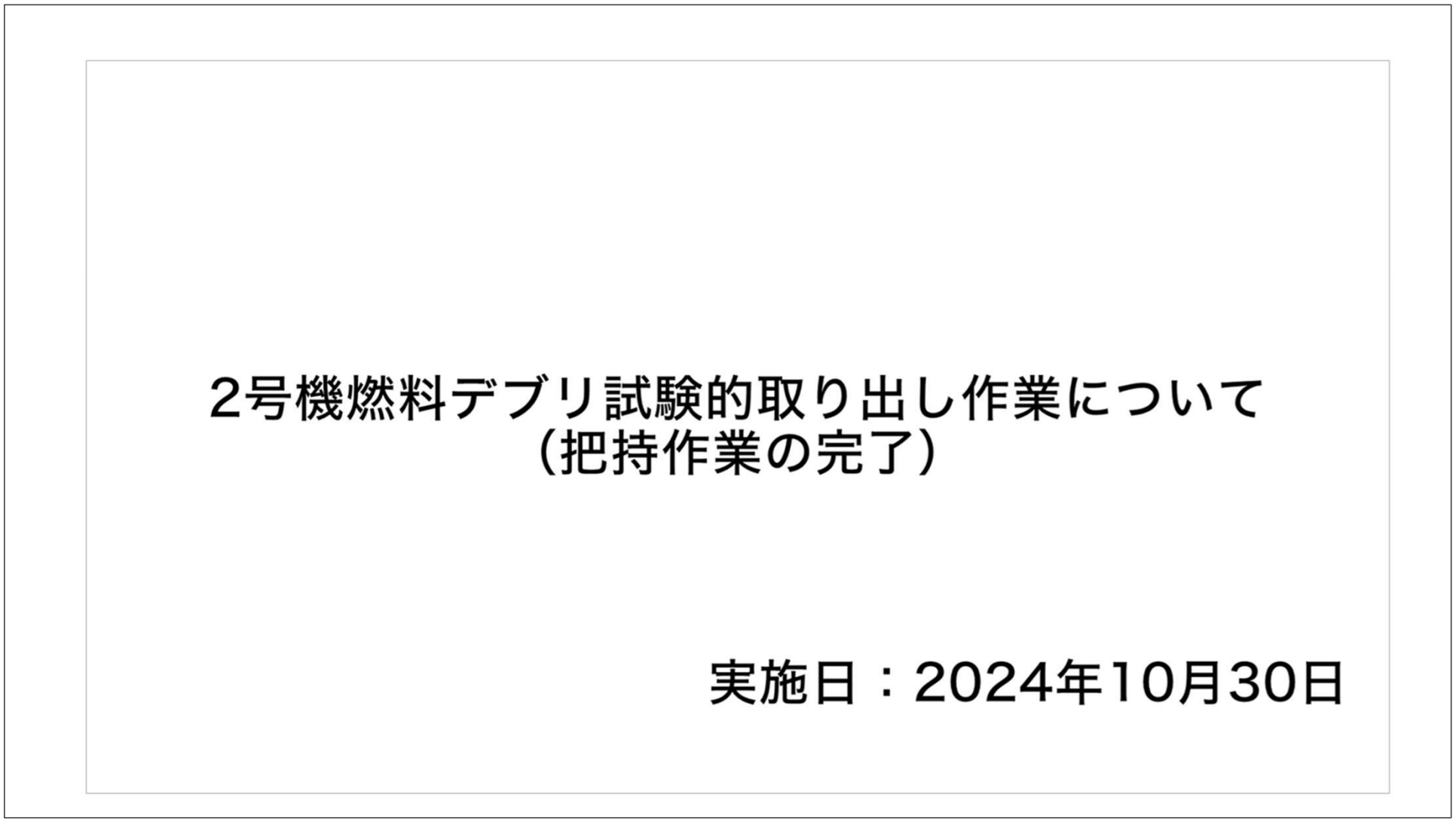




Inside the PCV

2. First Trial Retrieval

- **The telescopic equipment was transported into the reactor building in July 2024.**
- **Transportation of fuel debris off-site was completed in November of the same year, following two interruptions to the retrieval work.**



2. First Trial Retrieval

- **Workers were heavily equipped under high radiation environment, and worker's radiation does were not small.**
- **Troubleshooting was also necessary for issues such as incorrect connection order of push pipes and camera malfunctions.**

Work interruption due to incorrect connection order of push pipes

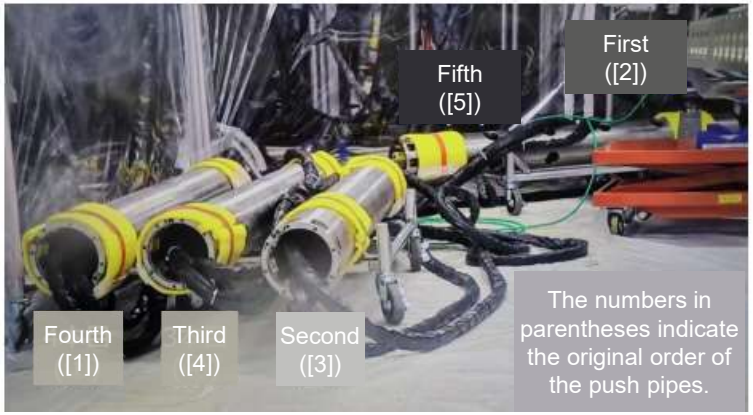
Overview

During the final on-site confirmation, it was found that the connection order of the push pipes was different from the plan.

Main Causes

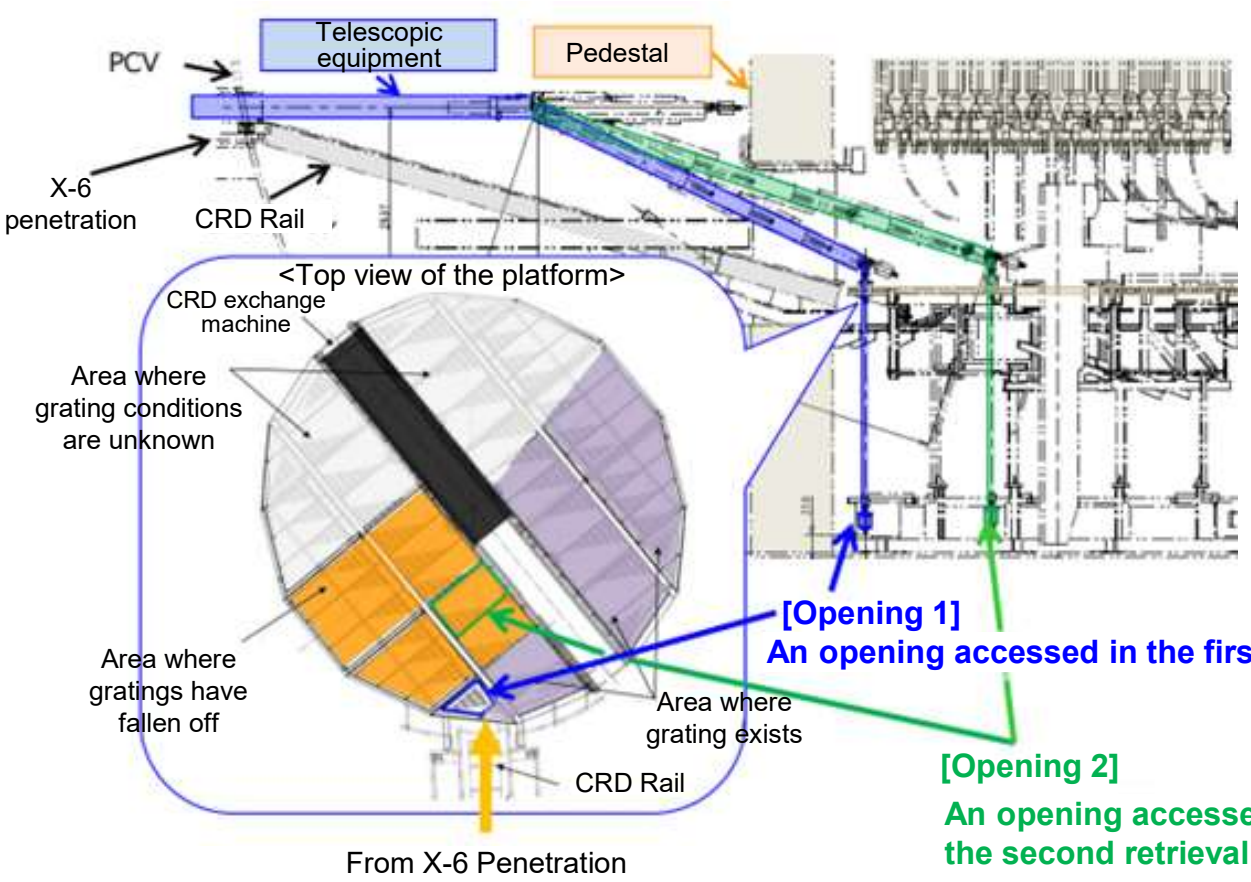
- ✓ Work performed by multiple heavily equipped teams in rotations due to high radiation levels
- ✓ Pipe ID numbers were difficult to identify
- ✓ Communication and confirmation were inadequate

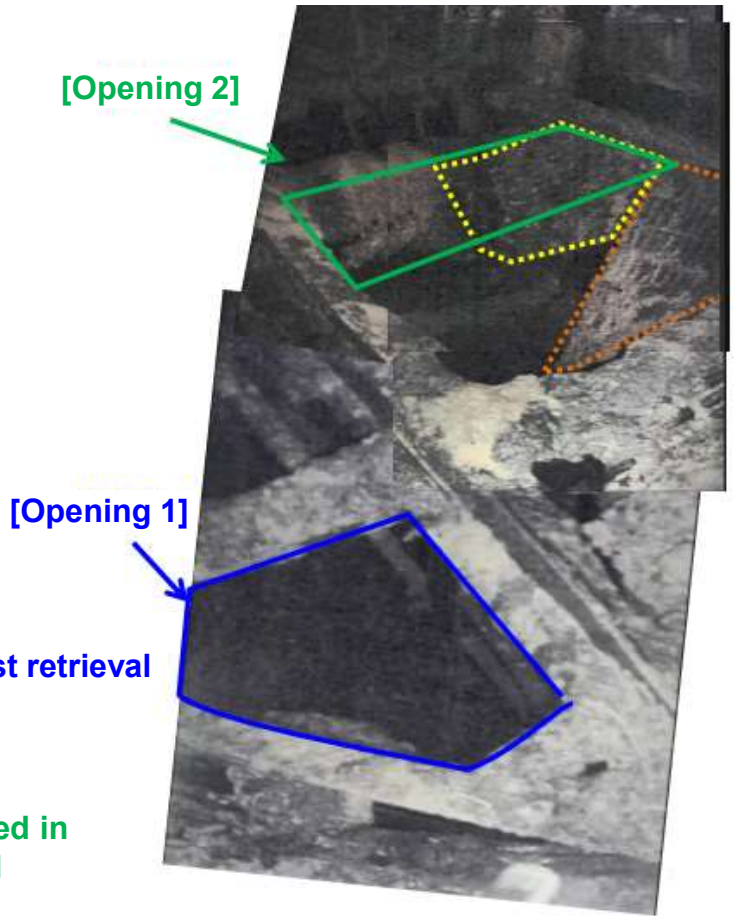
After improving identification method and reconfirming work procedures, the work resumed and the first fuel debris was sampled in November 2024.



3. Second Trial Retrieval

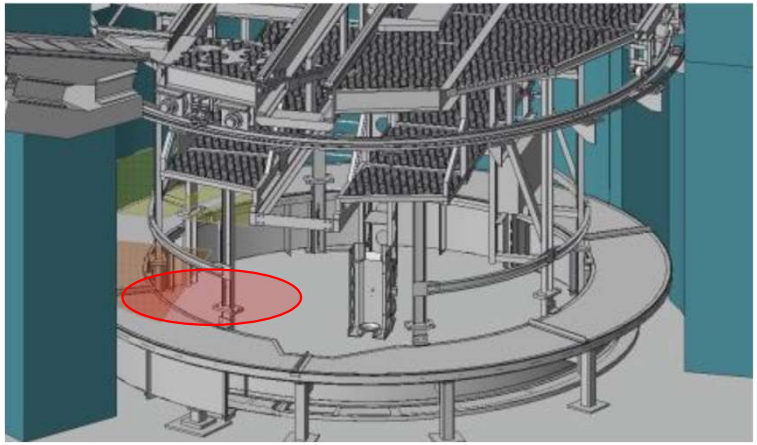
- **Fuel debris was sampled from a different location than the during the first retrieval.**
- **Work began in April 2025, and transportation of the fuel debris off-site was completed within the same month.**
  - ✓ Improvements to equipment and work procedures based on the lessons learnt from the first time
  - ✓ Improved work proficiency



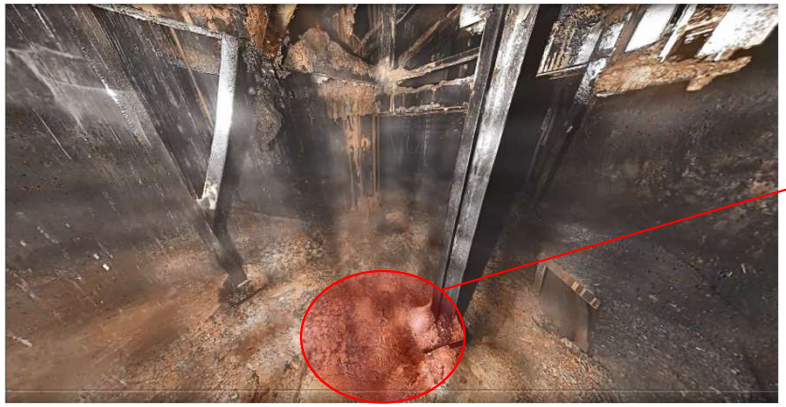


4. Fuel Debris Sampling Locations

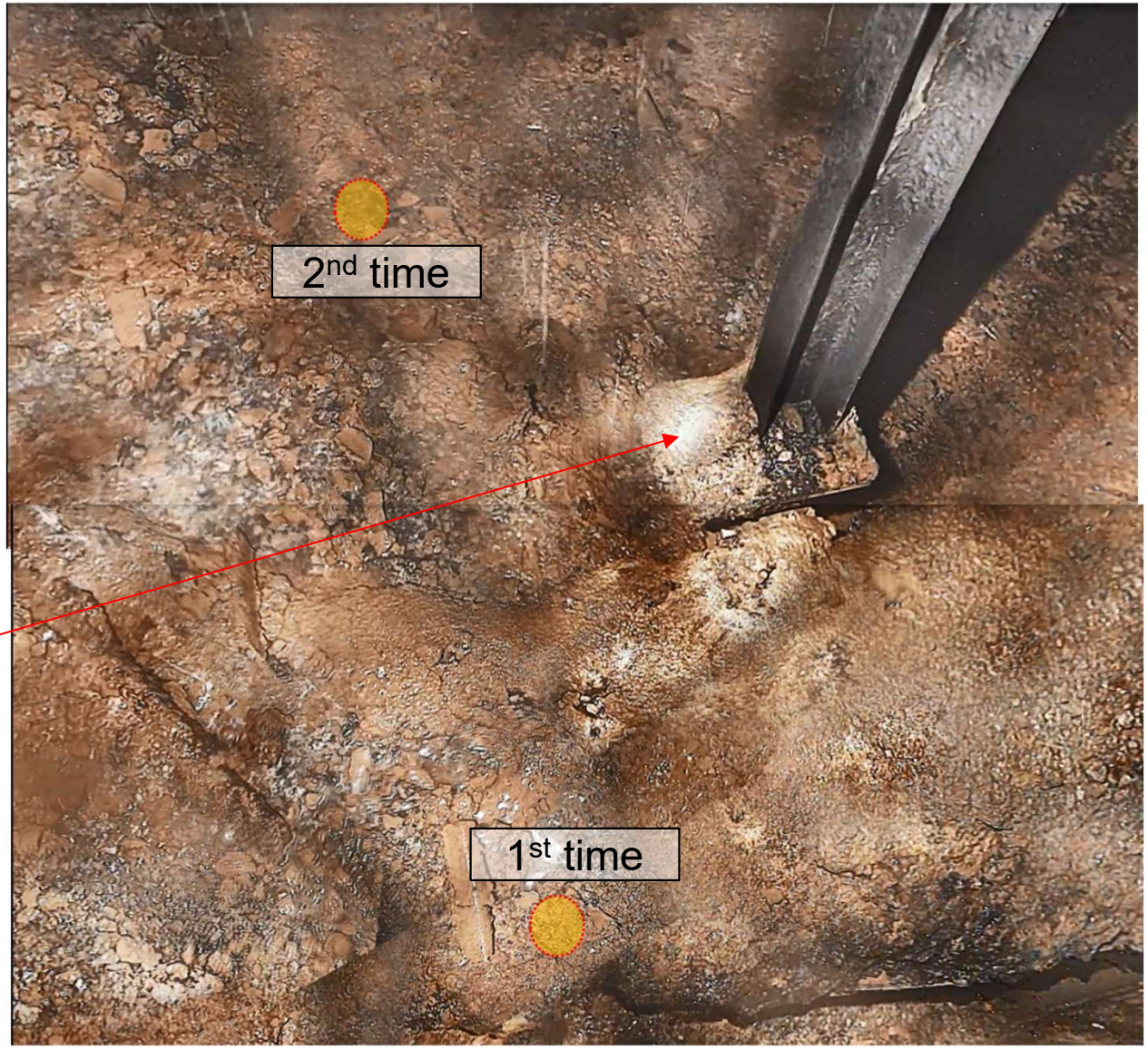
- **The estimated locations of fuel debris sampling have been overlaid onto past internal inspection images**



Pedestal



Panoramic image of
the bottom of Pedestal



※Composite image

5. Radiation Dose during the Trial Retrieval

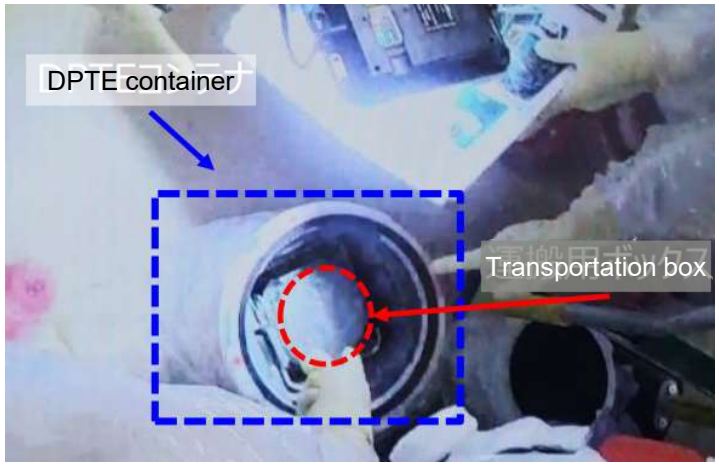
- **Work time per person per day in the reactor building was 15 to 30 minutes.**
- **In the second trial retrieval, both the total dose and the maximum individual dose decreased.**
  - ✓ Work progressed as planned
  - ✓ Improved work proficiency and efficiency.

	Total Dose		Maximum Individual Dose
	Equipment Installation	Trial Retrieval	
First time	Approx. 360 person-mSv	Approx. 360 person-mSv	Approx. 12 mSv
Second time	-	Approx. 140 person-mSv	Approx. 6 mSv

6. Analysis of Fuel Debris

- **Collected samples were transported to the JAEA off-site analytical facility.**

  ➡ Information obtained from analysis will be utilized for future decommissioning work and accident analysis.



Transportation box in container

Off-site transportation container

Fuel debris sample (first time)

Size: approx. 9 mm × 7 mm
Weight: 0.693 g
Dose rate (γ-ray): approx. 8 mSv/h

III. Status of Engineering Study for Full-Scale Retrieval

1. About Sub-Committee for the Evaluation of Fuel Debris Retrieval Methods

NDF established the "Sub-Committee for the Evaluation of Fuel Debris Retrieval Methods" in 2023

- ✓ Recommendations for selection of retrieval method were made in March 2024
- ✓ Sub-committee is currently following up on the status of TEPCO's design study.

List of Sub-Committee members (at present)

Chairman: Toyoshi Fuketa, Former Chairman of Nuclear Regulation Authority (currently NDF Head of Decommissioning)

Tatsuya Itoi, Associate Professor, School of Engineering, The University of Tokyo

Hiroto Uozumi, Former President & CEO, Atomic Energy Association

Koji Okamoto, Professor, Graduate School of Engineering, The University of Tokyo

Akira Kirishima, Professor, Institute of Multidisciplinary Research for Advanced Materials, Tohoku University

Takumi Saito, Professor, School of Engineering, The University of Tokyo

Kazuko Haga, Senior Executive Officer, Taiheiyo Consultant Company Limited

Toshikatsu Maeda, Director General, Nuclear Science Research Institute, Japan Atomic Energy Agency

Yoshihito Miyaike, Former President, Central Nippon Expressway Company Ltd.

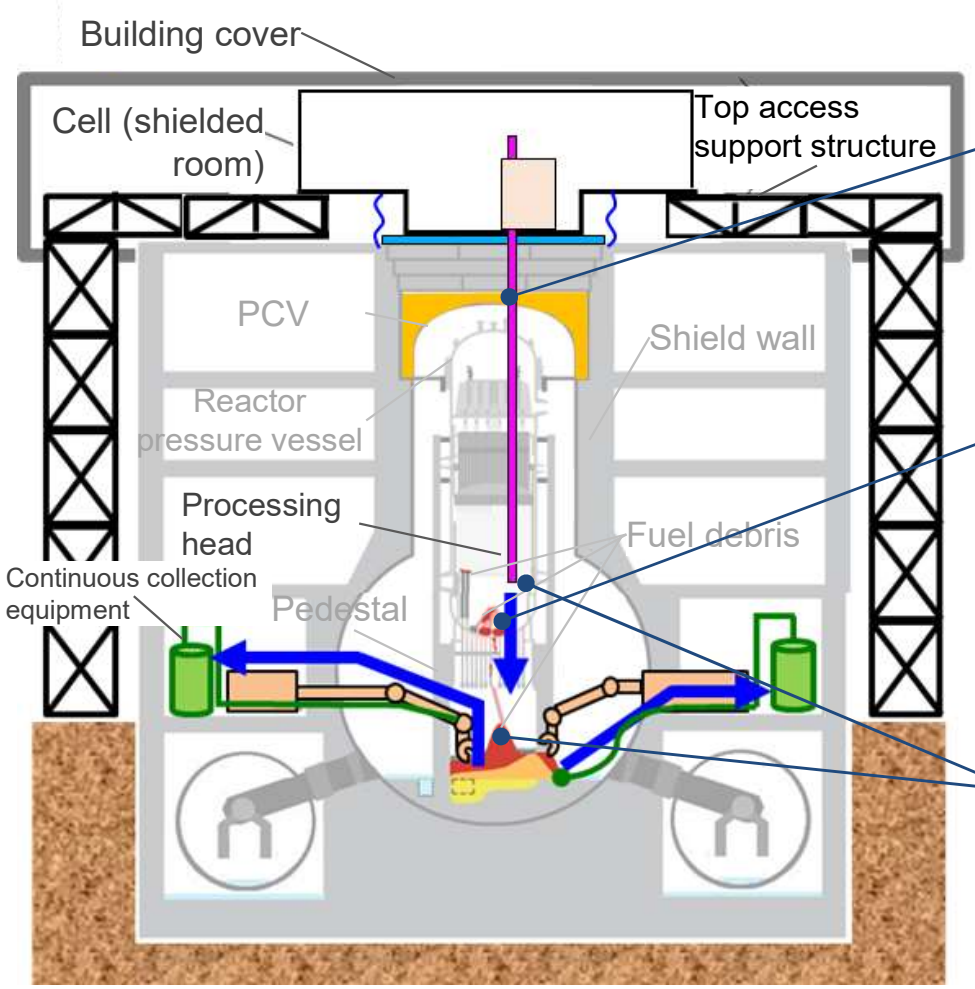
Akio Yamamoto, Professor, Graduate School of Engineering, Nagoya University

Hiroko Yoshida, Research Professor, Research Center for Accelerator and Radioisotope Science, Tohoku University

Hans Wanner, Former Director General, Swiss Federal Nuclear Safety Inspectorate (ENSI)

2. Overview of Fuel Debris Retrieval Method

- **Based on the recommendations, TEPCO is conducting a conceptual studies.**
- **Schedule for preparatory work prior to full-scale retrieval has recently been presented**



Fuel debris retrieval route

(1) Access from a small opening

- ✓ Shielding and equipment scale can be reduced
- ✓ Allows for manual work in case of breakdowns

(2) Unification and simplification of fuel debris handling

- ✓ Using lasers etc., cut fuel debris into small pieces
- ✓ Collect by suction from the side

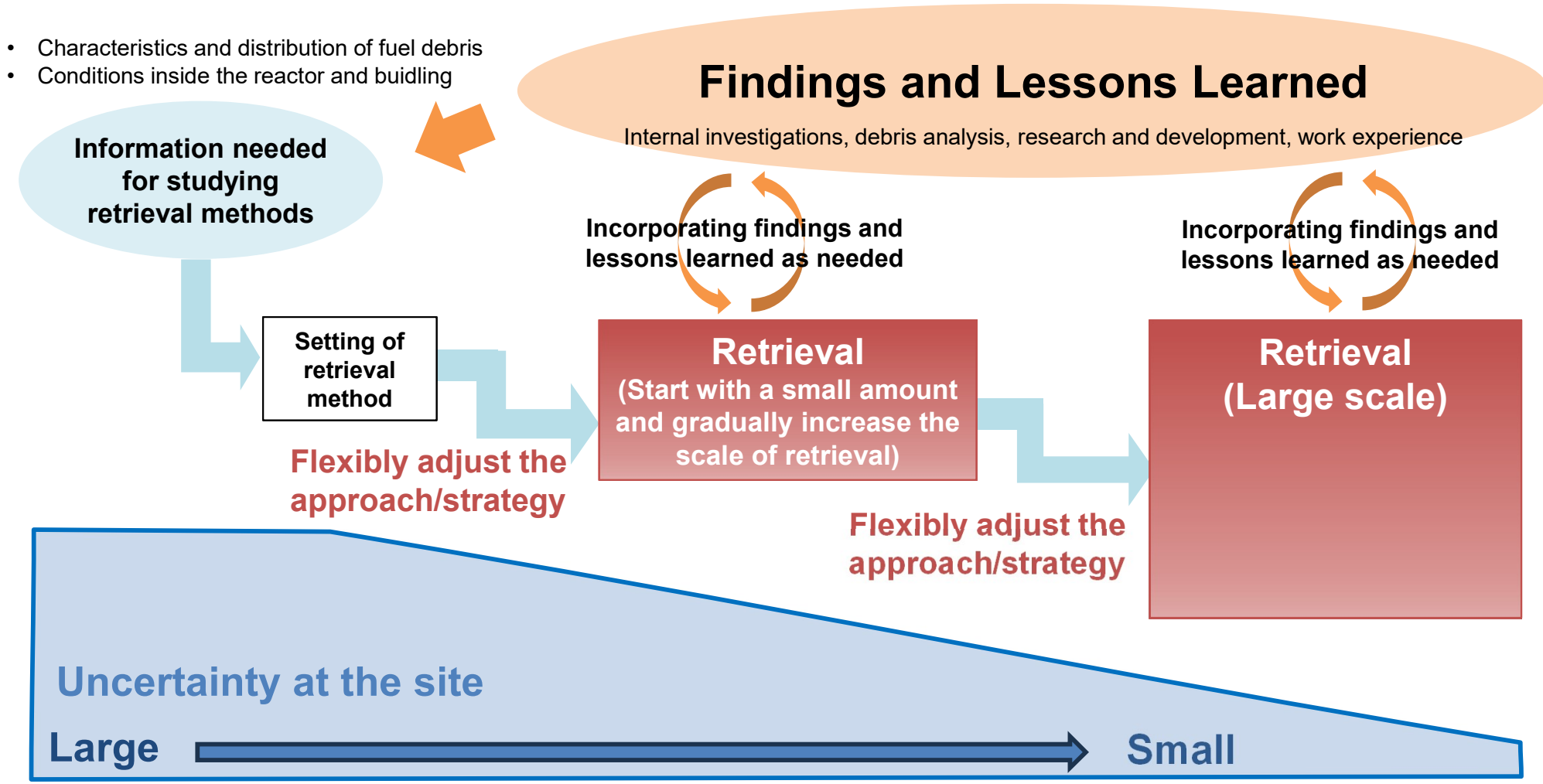
(3) Combination of top and side access

- ✓ Processing by top access and collection by side access
- ✓ For pedestal bottom, side access is applicable for processing and collection

3. Step-by-Step Approach

It is important to proceed with fuel debris retrieval step by step.

- ✓ It is difficult to plan large-scale engineering projects from the outset when significant uncertainties exist at the site.
- ✓ Start small and gradually expand the scale while gaining knowledge and lessons learned



Key considerations for Step-by-Step Approach

(1) Trial and error, and rework may occur at each stage.

- Review designs and work procedures through trial and error
- Expand the scale of retrieval while accumulating these experiences

(2) Ensuring work safety is the primary prerequisite.

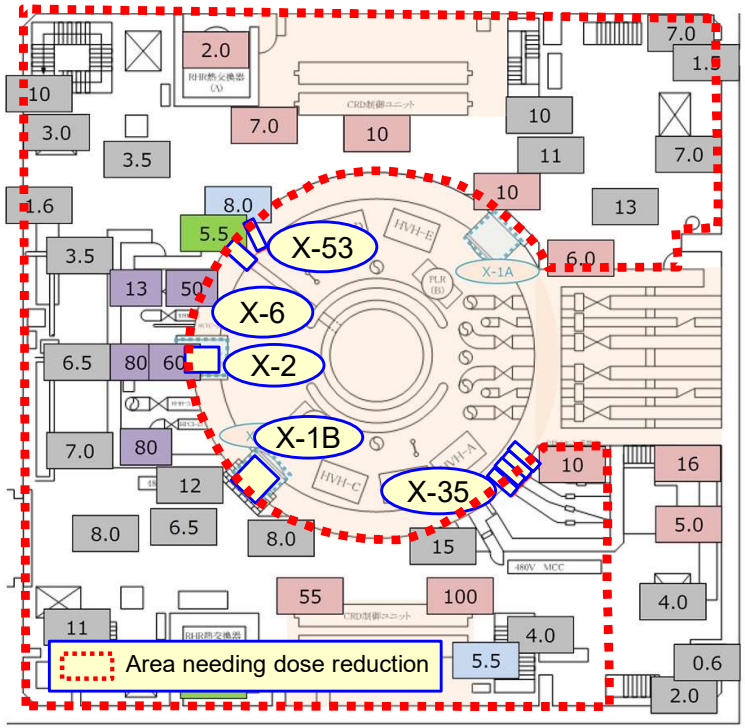
- Starting work within a scope where safety can be ensured and then expanding that scope is a prerequisite for long-term sustainable decommissioning work.
- Establishing a realistic path to risk reduction will lead to ensuring work safety.

4. Environmental Improvement

Before full-scale retrieval, it is important to conduct environmental improvement work both inside and outside the reactor building.

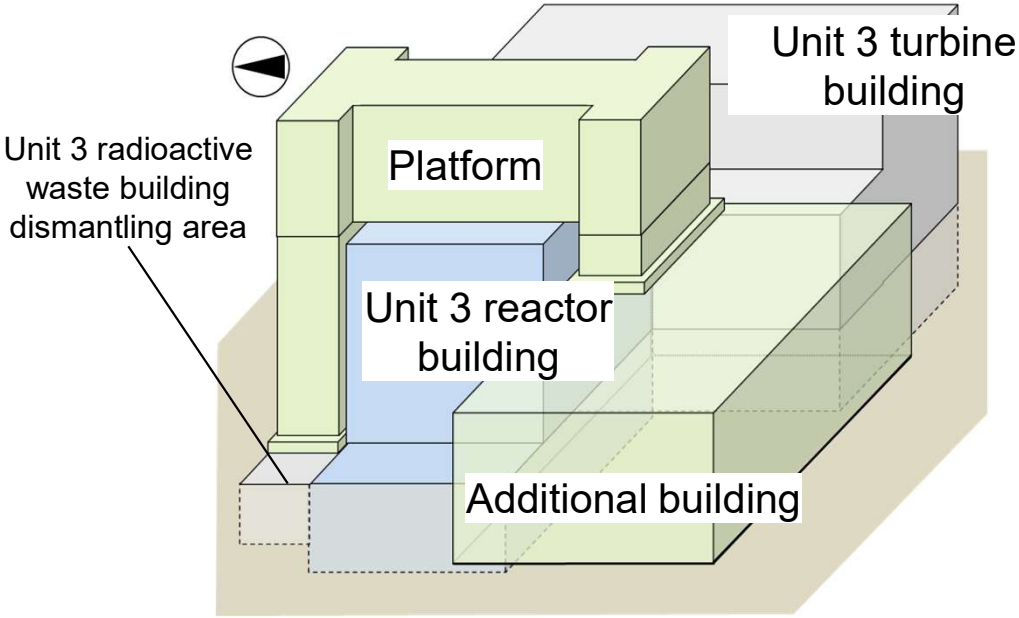
- To ensure worker safety, construct necessary facilities, and improve work efficiency
- Large impact on fuel debris retrieval method and period

(1) Dose reduction and removal of interfering objects inside the reactor building



✓ Important for dose reduction during installation and operation of the side-access retrieval equipment

(2) Removal of interfering facilities outside the reactor building



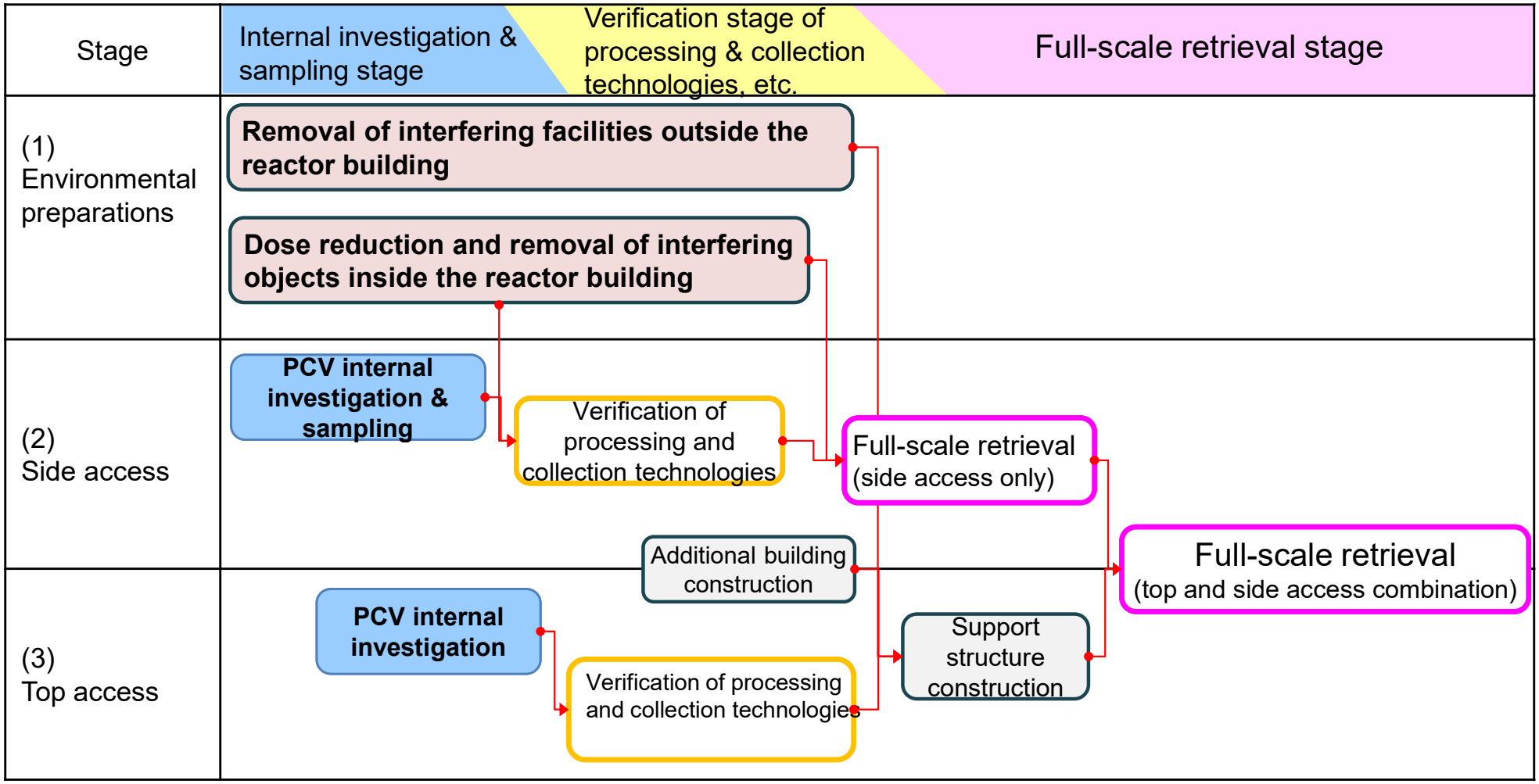
An example of a constructing support structure and an additional building (case of installing platform in the north-south direction)

✓ It requires to remove surrounding facilities that would interfere with retrieval operations.

5. Work Process for Fuel Debris Retrieval

Environmental improvement work and internal investigations have a significant impact on the retrieval work.

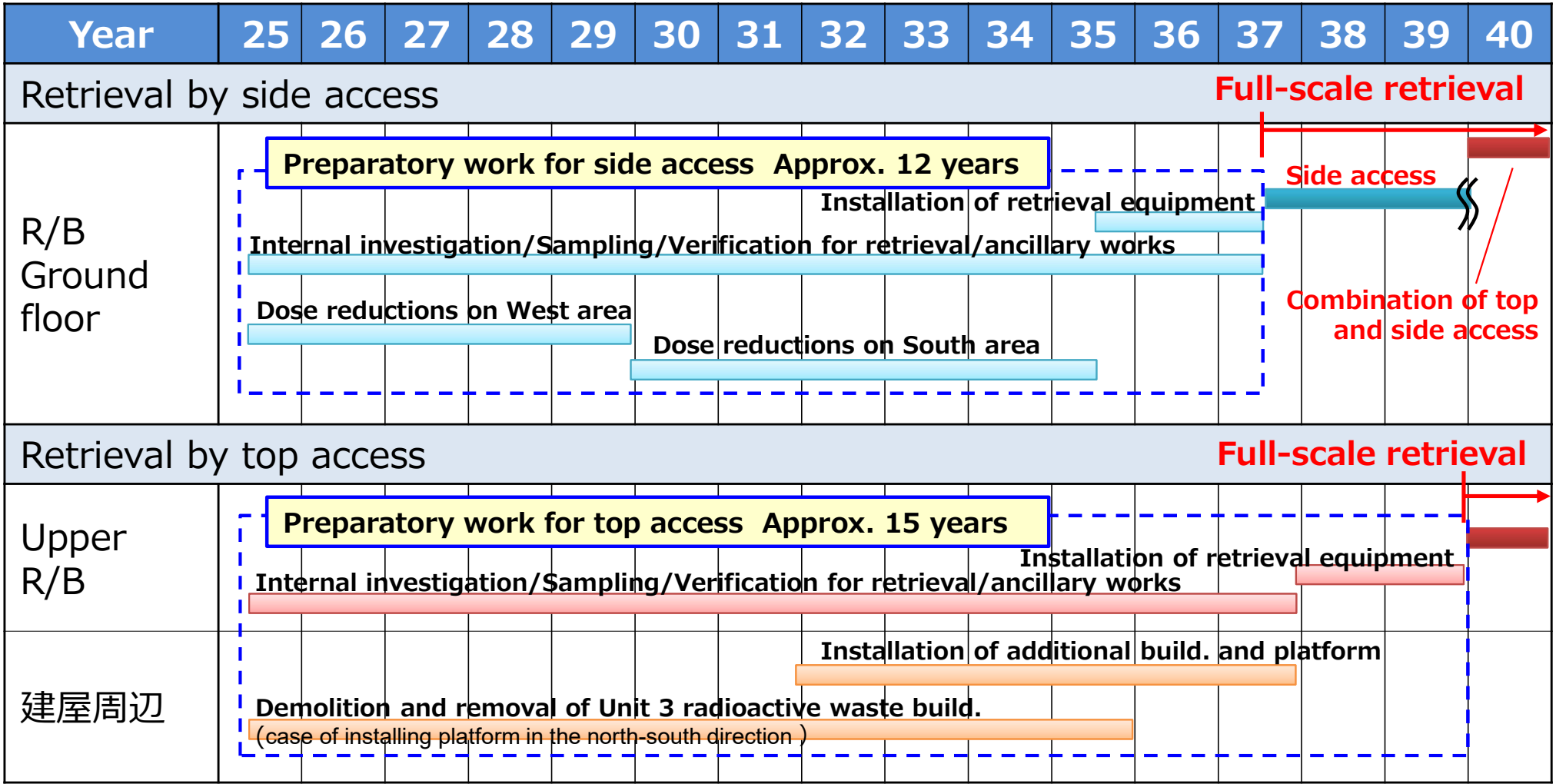
- ✓ In addition to environmental improvement, internal investigations are also important.
- ✓ These are important preparatory work for full-scale fuel debris retrieval.



5. Work Process for Fuel Debris Retrieval - Preparatory Work

An estimated 12 to 15 years is expected for the preparatory phase prior to full-scale fuel debris retrieval.

- ✓ The preparatory work phase includes certain assumptions, and further verifications and study will be conducted over the next 1-2 years.
- ✓ The schedule following the start of full-scale retrieval involve significant uncertainties and will be further studied during the preparatory work phase



6. Required Approach to Decommissioning Work

Required approach to future decommissioning work:

(1) Integrated and timely decision-making at the site

- ✓ Make decisions based on a holistic understanding of diverse on-site information and perspectives
- ✓ Adjust directions in timely and appropriately according to on-site conditions and new findings
- ✓ Support regulatory decision through smooth information sharing and communication

(2) Prioritization and strategic resource allocation

- ✓ Resource allocation based on a long-term perspective and on-site situations
- ✓ Consistency of priorities between whole and its parts (avoiding silos)

With safety being ensured as the highest priority, steady and flexible progress needs to be made with on-site work involving significant uncertainties..

IV. Summary

Towards Safe and Reliable Fuel Debris Retrieval

Efforts are currently underway toward fuel debris retrieval.

- Two trial retrievals were conducted.
- Conceptual studies of large-scale retrieval methods are also underway.

However, various difficulties and challenges may continue to arise in the complex and long-term decommissioning of Fukushima Daiichi.

- As work progresses, unexpected challenges and difficulties may arise.
- Consider not only individual technical issues but also overall approach to decommissioning work

In particular, the key issue is how to proceed safely and steadily with the decommissioning work while dealing with uncertainties.

- Without work safety, it is impossible to steadily progress with long-term work.
- Learning from findings and lessons from actual work, and incorporating flexibly into operations and plans will contribute to improving safety.

Key Important Points for Future Endeavors

(1) Step-by-Step Approach

- Start work within a scope where safety can be ensured, and then expand that scope
- Accept trial and error, and temporary rework as necessary steps.

(2) Enhancing Environmental Improvement

- Important foundational work affecting worker safety, retrieval methods and schedules

(3) Overall Approach to Future Decommissioning Work

- Integrated and timely decision-making
- Prioritization and strategic resource allocation